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(56) Documents Cited
GB 2286317 A **EP 0849910 A2** **WO 97/31451 A1**
US 6040834 A **US 5615323 A** **US 5471399 A**

(58) Field of Search
UK CL (Edition R) **H4K KFM , H4P PEUL PFD**
INT CL^7 **H04L 12/24 12/26 , H04Q 3/00**
ONLINE: WPI, EPODOC, JAPIO.

(54) Abstract Title
Network management apparatus with graphical representation of monitored values

(57) A network management apparatus (3A) and method for processing network management data receives values for a monitored characteristic of a part of a network (1). Each time a new value for the monitored characteristic is received, a statistical value representing a level of the monitored characteristic over time is calculated. In one embodiment, the statistical value is a statistical average of received values over time, and in another embodiment the statistical value is the number of times the value of the monitored characteristic exceeds a predetermined threshold, for instance indicating high stress. The statistical value is then used to determine a graphical representation of the part of the network. For instance, an icon representing a device on the network has a size in proportion with the statistical value. Similarly, a line representing a link on the network has a thickness depending upon the statistical value. The determined graphical representation is then used in the display of a network map (17A)(Fig.3). Alternatively, the colour of an icon may change in dependance upon the statistical value.

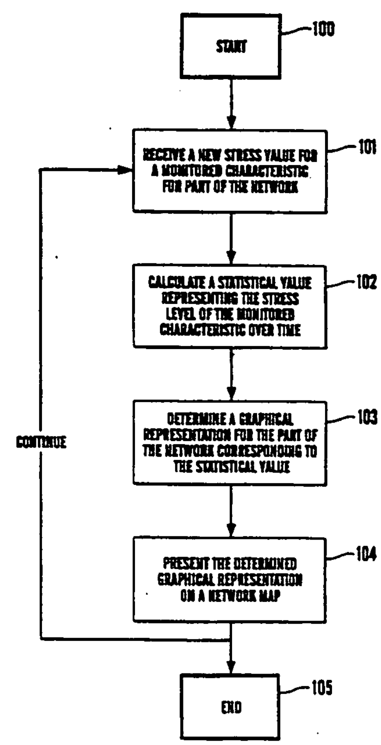

Fig.4

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 362 062 A

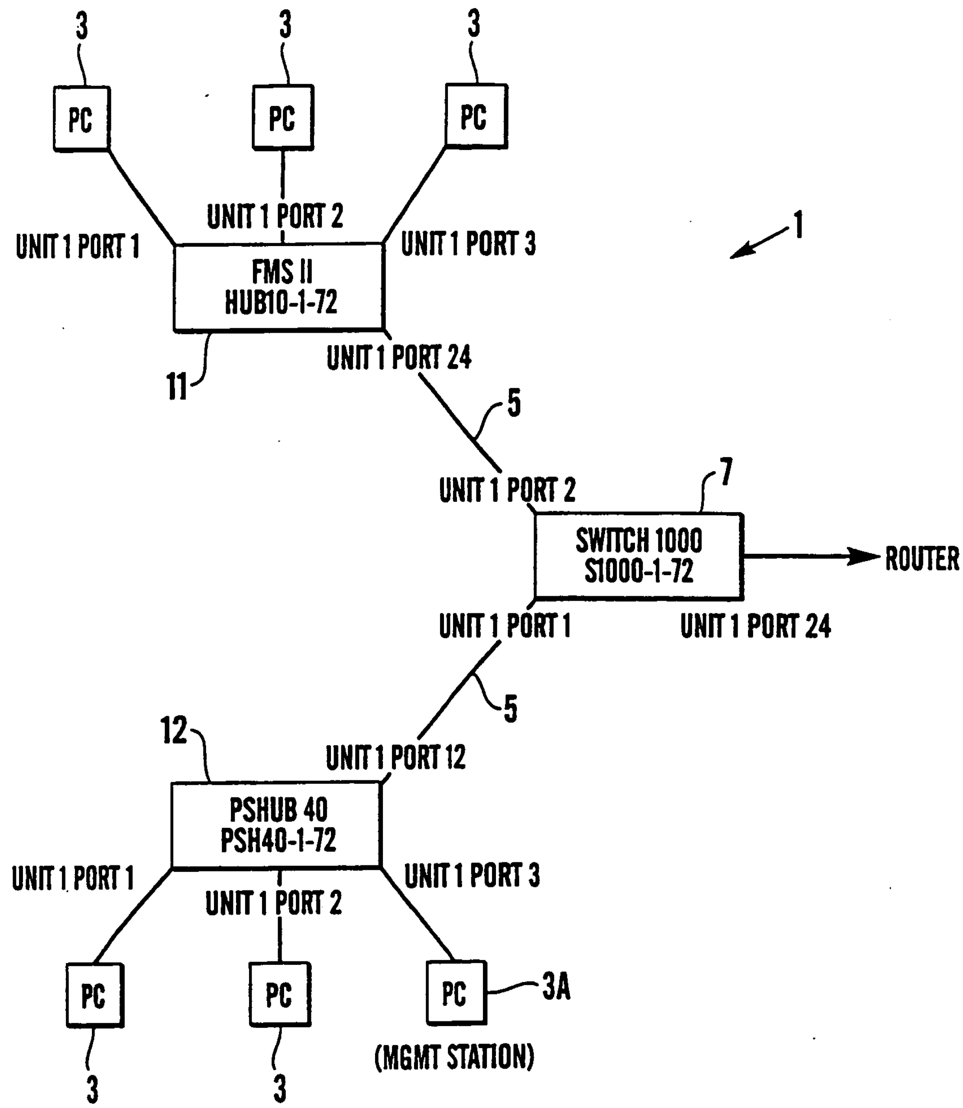
3
3
3
PC
PC
PC
UNIT 1 PORT 2
UNIT 1 PORT 1
UNIT 1 PORT 3
1
FMS II
HUB10-1-72
UNIT 1 PORT 24
11
5
UNIT 1 PORT 2
7
SWITCH 1000
S1000-1-72
ROUTER
UNIT 1 PORT 1
UNIT 1 PORT 24
5
12
UNIT 1 PORT 12
PSHUB 40
PSH40-1-72
UNIT 1 PORT 1
UNIT 1 PORT 2
UNIT 1 PORT 3
PC
PC
PC
3A
(MGMT STATION)
3
3

Fig. 1

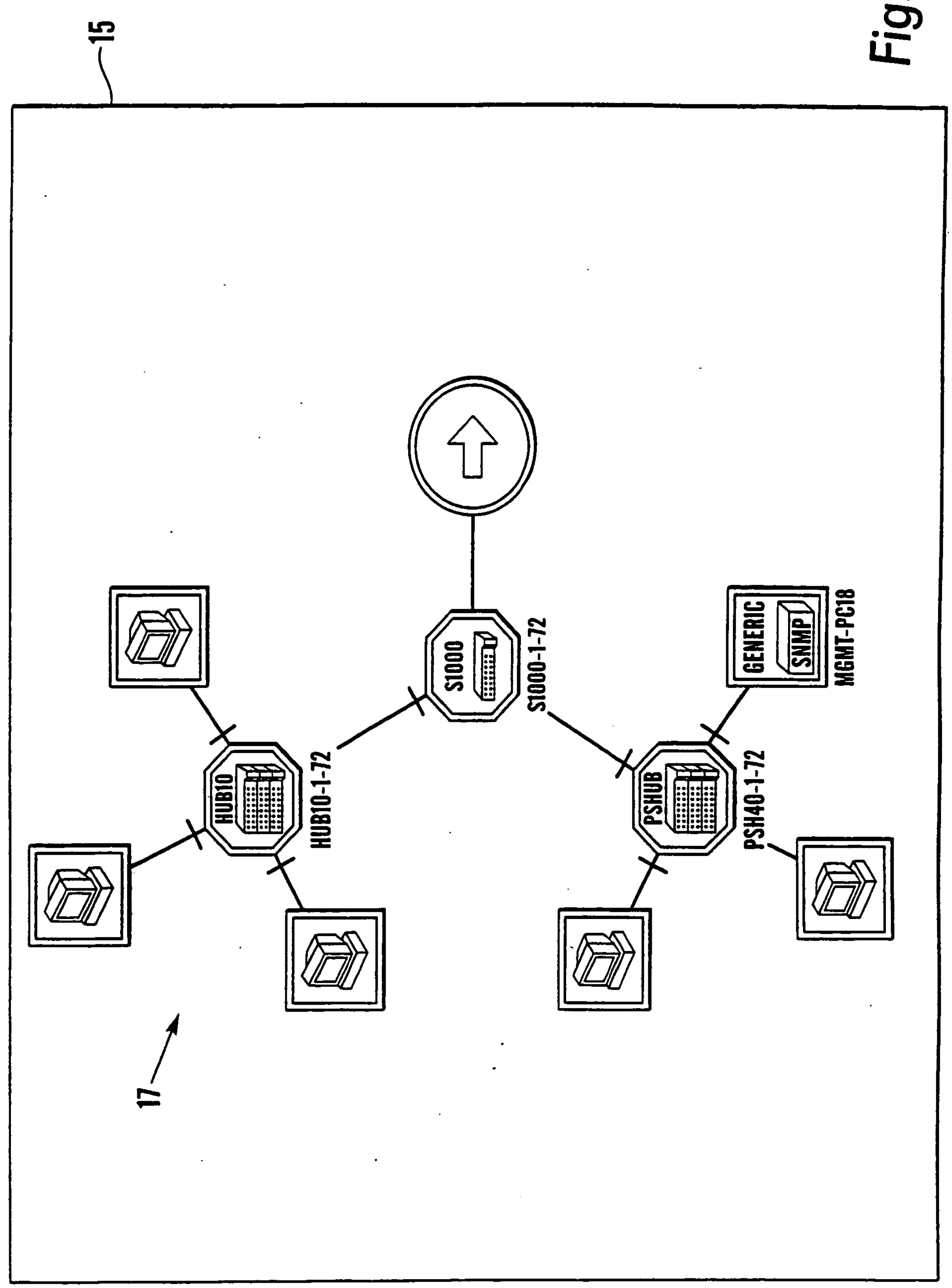
15
S1000
S1000-1-72
HUB10
HUB10-1-72
PSHUB
PSH40-1-72
GENERIC
SNMP
MGMT-PC18
17

Fig.2

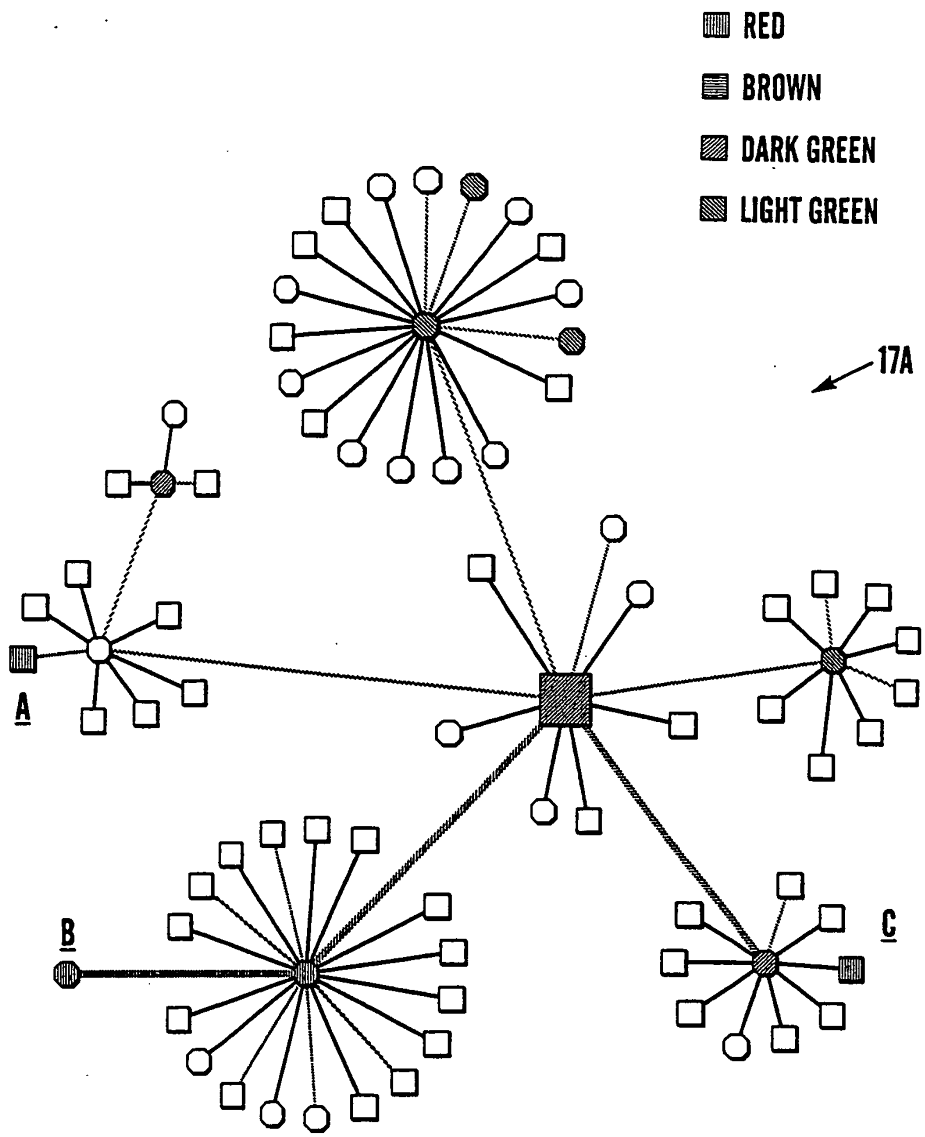

Fig.3

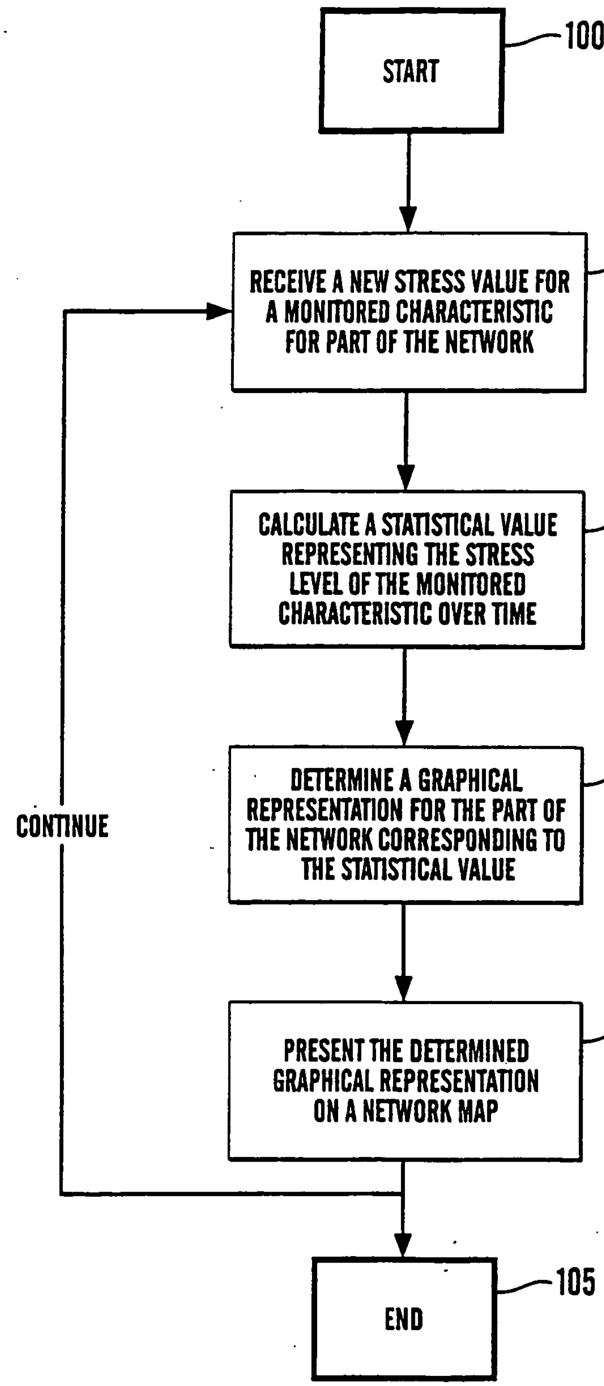
START
100
RECEIVE A NEW STRESS VALUE FOR A MONITORED CHARACTERISTIC FOR PART OF THE NETWORK
101
CALCULATE A STATISTICAL VALUE REPRESENTING THE STRESS LEVEL OF THE MONITORED CHARACTERISTIC OVER TIME
102
DETERMINE A GRAPHICAL REPRESENTATION FOR THE PART OF THE NETWORK CORRESPONDING TO THE STATISTICAL VALUE
103
PRESENT THE DETERMINED GRAPHICAL REPRESENTATION ON A NETWORK MAP
104
CONTINUE
END
105

Fig.4

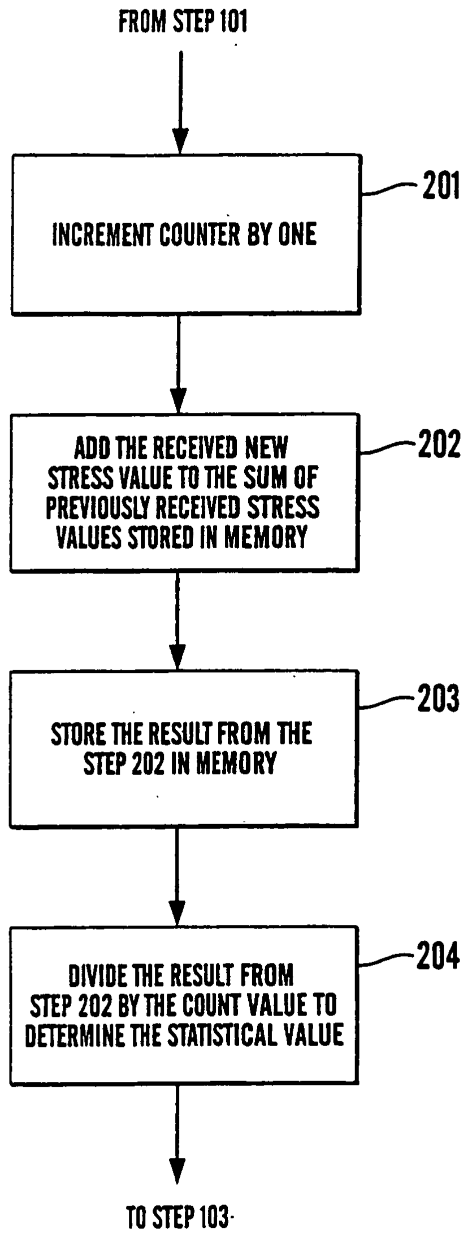
FROM STEP 101
INCREMENT COUNTER BY ONE
201
ADD THE RECEIVED NEW STRESS VALUE TO THE SUM OF PREVIOUSLY RECEIVED STRESS VALUES STORED IN MEMORY
202
STORE THE RESULT FROM THE STEP 202 IN MEMORY
203
DIVIDE THE RESULT FROM STEP 202 BY THE COUNT VALUE TO DETERMINE THE STATISTICAL VALUE
204
TO STEP 103

Fig.5

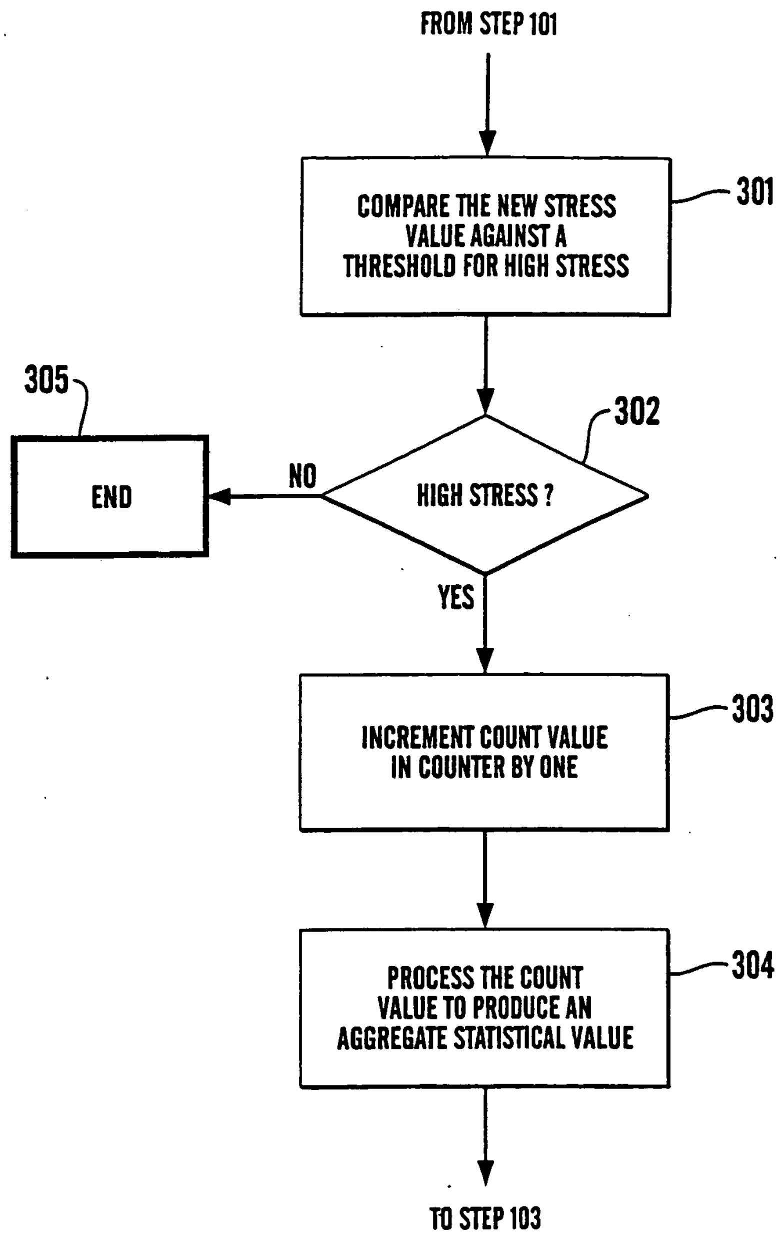
FROM STEP 101
COMPARE THE NEW STRESS VALUE AGAINST A THRESHOLD FOR HIGH STRESS
301
305
END
NO
HIGH STRESS ?
302
YES
INCREMENT COUNT VALUE IN COUNTER BY ONE
303
PROCESS THE COUNT VALUE TO PRODUCE AN AGGREGATE STATISTICAL VALUE
304
TO STEP 103

Fig.6

NETWORK MANAGEMENT APPARATUS AND METHOD FOR MONITORING STRESS OF A NETWORK

The present invention relates generally to an apparatus and method for the management of a network, and more particularly to a network management apparatus and method for use in monitoring the health or stress of a network.

The following description is concerned with a data communications network, and in particular a local area network (LAN) but has more widespread applicability to other managed communications systems including wide area networks (WANs) or wireless communications systems.

Networks typically comprise a plurality of computers, peripherals and other electronic devices capable of communicating with each other by sending and receiving data packets in accordance with a predefined network protocol. Each computer or other device on the network is connected by a port to the network media, which in the case of a LAN network may be coaxial cable, twisted pair cable or fibre optic cable. Each device on the network typically has hardware for media access control (MAC) with its own unique MAC address. Data packets are sent and received in accordance with the MAC protocol (e.g. CSMA/CD protocol as defined by the standard IEEE 802.2, commonly known as Ethernet). Data packets transmitted using the MAC protocol identify the source MAC address (i.e. the MAC address of the device sending the data packet) and the destination MAC address (i.e. the MAC address of the device for which the data packet is destined) in the header of the data packet.

A network is generally configured with core devices having a plurality of ports, which can be used to interconnect a plurality of media links on the network. Such devices include hubs, routers and switches which pass data packets received at one port to one or more of its other ports, depending upon the type of device. Such core devices can either be managed or unmanaged.

It is becoming increasingly common for an individual, called the network administrator, to be responsible for network management, and his or her computer system or workstation is typically designated the network management station. The network management station incorporates the manager, as defined in the SNMP protocol, i.e. the necessary hardware, and software applications to retrieve data from MIBs by sending standard SNMP requests to the agents of managed devices on the network.

Network management software applications are known which can determine the topology of a network, i.e. the devices on the network and how they are linked together. In order to determine the network topology, the application retrieves data from the managed devices on the network, which data can provide information about the devices connected to the managed devices, for instance the aforementioned "address tables". MIB data can also be retrieved from managed devices to provide information about device type, device addresses and details about the links. Using such data, the application can usually determine the topology of the entire network.

An example of a known network management software application capable of determining network topology is the Transcend® Network Supervisor application available from 3Com Corporation of Santa Clara, California, USA.

A part of the network administrator's function is to identify and resolve problems occurring on the network, such as device or link malfunction or failure. In order to provide the network administrator with the necessary information to identify such problems, the network management application monitors the devices on the network. An example of such monitoring is described in co pending UK Patent Application No 9917993.9 entitled "Management System and Method for Monitoring Stress in a Network" in the name of the present applicant. In the system and method described in UK Patent Application No 9917993.9 the SNMP manager in the network management station requests the agents of managed network devices on the network device to retrieve selected MIB data indicative of device and link operation, and

An alternative way of presenting the monitored data to the network administrator is to display a graphical representation of the network as a "network" map. Each device on the network is represented by an appropriate device icon and the links between devices are represented by lines connecting the device icons on the network map. The monitored stress values for each device and link are displayed in association with the corresponding icon on the network map (e.g. by clicking on a device icon to open a window showing the monitored values). The icons representing devices and lines representing links may be coloured to represent the stress levels. For example, the colour green may be used for low stress levels, and red may be used to represent high stress levels.

A problem with this method of presenting management data to the network administrator is that the network map represents the most recently monitored stress levels associated with the network. It does not reflect past performance and cannot provide clues to problems found previously, since the network map is continually updated as the devices are monitored. Thus, if a malfunctioning device or link happens to be working at the time the administrator views the network map, the administrator is not alerted to the problem.

It would be desirable to provide a network management system and method which addresses the aforementioned problems.

In accordance with a first aspect, the present invention provides a method for processing network management data comprising: receiving a new value for a monitored characteristic of a part of a network for which at least one previous value has been received; calculating a statistical value representing a level of the monitored characteristic over time, and determining a graphical representation of the part of the network corresponding to the statistical value.

The method can thus be used to produce a graphical representation for use in a network map to visibly distinguish parts of the network which have a history of high

Figure 1 shows a typical local area network 1. The network 1 operates various protocols within the TCP/IP protocol suite, as described above. The network 1 includes SNMP managed network devices including hubs 11 and 12, and switch 7 which are connected together by media links 5. End stations, in the form of personal computers (PCs) 3 are provided for users, including management station 3A for the network administrator. The PCs 3 are unmanaged network devices. Each PC 3 is connected to a core managed device, such as hub 11, which in turn is connected to switch 7. The hubs 11 and 12 and switch 7 are managed devices which communicate management information with management station 3A using the SNMP protocol. The agent within each core managed network device monitors data traffic passing through its ports and stores the data thereby obtained in an appropriate location in a MIB. Typically, the MIB data is represented in the form of "conceptual tables" (called "MIB tables") as is well known in the art. A typical managed device may implement a number of MIBs for network management.

An example of a MIB containing network management data is MIB-II (formerly MIB-I) defined by RFC 1213: Management Information Base for Network Management of TCP/IP Internets. In the network 1, hubs 11 and 12 and switch 7 store MIB-II data. Another MIB containing more complex management data is RMON (as defined in RFC 1757: Remote Network Monitoring Management Information Base) and in the network 1, only switch 7 stores RMON data.

Figure 2 shows a map 17 of the network 1 of Figure 1. Such a network map 17 is produced using a conventional network management software application, such as the Transcend® Network Supervisor application available from 3Com Corporation of Santa Clara, California, USA. Such a network management application "discovers" the network topology by interrogating the managed network devices i.e. hubs 11 and 12 and switch 7 on the network using the SNMP protocol. The data received is then processed to determine the number and type of network devices on the network, and how they are linked together. This information is then used to produce the network map which is displayed on a display screen 15 of the network

and 12 and switch 7, and RMON data from switch 7 and processing the received data, and by periodically polling all network devices using Ping or service requests and monitoring response times. For Ping and service requests, the management station 3A waits a predetermined period of time before it considers that a response has not been received and the request is "timed out".

The network management station 3A indicates the thus determined stress values in association with the network map 17. For instance, if no response is received to an IP Ping of an endstation 3, the network map will illustrate the endstation icon in red. Clicking on the icon will reveal further details i.e. that the endstation has a high level of stress because no response was received to the most recent IP Ping from the network management station 3A.

The network map 17 is continually updated, each time the network management station 3A receives a new stress value during its monitoring process. Thus, the network map 17 only represents the stress of the network 1 at a particular moment in time and does not represent past stress levels indicating past performance.

In accordance with a preferred embodiment of the present invention, the network management station 3A generates, either in addition to or in place of the conventional network map 17, a network map 17A representative of past and current stress levels. In particular, the network management station 3A determines an aggregate or average stress level for each monitored stress metric for each part of the network 1 and represents the average or aggregate stress levels on the network map.

Figure 3 shows a network map 17A of a more complex network representing the aggregate or average stress levels generated in accordance with the preferred embodiment. The network map 17A uses different colours for map icons and lines, different line thicknesses and different icon sizes to represent the aggregate or average stress level for the corresponding device or link.

slightly thicker than those representing low aggregate stress. Devices under high aggregate stress are represented by large red icons, and links under high stress are represented by thick red lines.

This may be achieved using an algorithm which maps an aggregated stress level onto a corresponding graphical representation of the device or link on the network map.

For example, consider an arbitrary numeric range for aggregated stress values for a link, such as 0 to 100, where 0 is minimum stress and 100 is maximum stress. An aggregate stress ("stress") for a link of 0 will map onto a line of minimum width ("min width" e.g. 1 pixel width) coloured "saturated green". An aggregate stress for a link of 100 will map onto a line of maximum width ("max width" e.g. 3 pixels) coloured "saturated red". Aggregate stress values between 0 and 100 will map linearly according to the following equations:

line width = min width + ((max width - min width) / 100) * stress

line colour = stress / 100 * (saturated red) + (1 - (stress / 100)) * (saturated green)
where the '+' operation indicates a mixing of the two colours.

A similar operation could be used to map the aggregate stress values for a device to a corresponding size and colour of icon.

The differences in size of the icons and lines and/or the use of colour in the network map 17A, enables the network administrator to readily identify areas of the network having high stress and to determine whether the parts of the network under high stress are related or isolated.

For instance, Figure 3 shows that there are a group of devices and links under high stress around node B. These problems are probably related. The high stress

ends at step 105 unless, in the meantime, it receives a new stress value, in which case the program continues from step 101.

Figure 5 shows the program substeps performed in step 102 of Figure 4 in accordance with a first example. In this first example, the program calculates an average stress value for the monitored characteristic. The stress value may be a normalised stress value, for instance determined as described in UK Patent Application No 9917993.9, or a stress value otherwise determined using raw data obtained during monitoring of the stress metric. The program stores the sum of previously received stress values for the monitored metric in memory and has a counter the value of which represents the number of stress values received for the monitored metric.

According to the substeps shown in Figure 5, when a new stress value is received by the program at step 101 of Figure 4, in step 201, the counter is incremented by one. The received stress value in step 102 is then added to the sum of previously received stress values for the monitored metric in step 202. This is achieved by retrieving the sum from memory, and adding it to the new stress value. The result is then stored in memory at step 203. The value stored in step 203 is then divided by the count value of the counter resulting from step 201, in step 204, thus determining the average stress value. The program then continues with step 103 of Figure 4.

Figure 6 shows the substeps performed by the program in step 102 of Figure 4, in accordance with a second example. In the second example, the value determined in step 102 is an aggregate value representing the number of times the stress value for the monitored characteristic of the relevant part of the network is high i.e. the stress value indicates unacceptable performance. As previously described, threshold values for each stress metric are predetermined, and stress values greater than or equal to the threshold are considered to represent high stress, and are considered to represent "Events".

CLAIMS:

1. A method for processing network management data comprising

receiving a new value for a monitored characteristic of a part of a network for which at least one previous value has been received;

calculating a statistical value representing a level of the monitored characteristic over time, and

determining a graphical representation of the part of the network corresponding to the statistical value.

2. A method as claimed in claim 1, wherein the monitored characteristic relates to the stress of the part of the network.

3. A method as claimed in claim 1 or claim 2, wherein the statistical value is a statistical average of received values for the monitored characteristic.

4. A method as claimed in claim 3, wherein the statistical average is determined by the steps of:

adding together the new value and the at least one previously received values for the monitored characteristic to produce a total; and

dividing the total by the number of received values for the monitored characteristic.

5. A method as claimed in claim 4, further comprising storing the total in memory.

6. A method as claimed in claim 4 or claim 5, further comprising, after the step of receiving a new value and before the step of calculating, incrementing a counter by one, wherein the count value of the counter represents the number of received values for the monitored characteristic.

16. A method for processing network management data substantially as hereinbefore described, with reference to, and as illustrated by Figures 4 and 5 or Figures 4 and 6 of the accompanying drawings.

17. A computer readable medium carrying a computer program for carrying out the method as claimed in any one of claims 1 to 16.

18. A network management apparatus for operating the method as claimed in any one of claims 1 to 16.

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Application No:	GB 0009114.0	**Examiner:**	Stephen Brown
Claims searched:	1-18	**Date of search:**	17 October 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4P (PFD, PEUL), H4K (KFM).

Int Cl (Ed.7): H04L: 12/24, 12/26, H04Q: 3/00.

Other: Online: WPI, EPODOC. JAPIO.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2 286 317 A	(Fujitsu) See especially fig.s 2, 4, 10, and page 4, line 36, to page 6, line 16, and page 8, lines 30-37.	1 at least
Y	EP 0 849 910 A2	(Northern Telecom) See especially the abstract, figure 18, and column 32, line 13.	1 at least
Y	WO 97/31451 A1	(MCI) See especially figure 5 and page 23, line 10, to page 28, line 7.	1 at least
Y	US 6 040 834	(Cisco) See especially figures 4-9, and column 6, line 17, to column 9, line 11, and claim 16.	1 at least
Y	US 5 615 323	(Concord) See especially column 3, line 55, to column 4, line 13, column 6, lines 10-59, and figure 2.	1 at least
Y	US 5 471 399	(Hitachi) See especially figures 13, 14, 16, 20 & 21, and column 8, lines 21-30, and column 9, line 58, to column 10, line 56.	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.